Notes on the MHATT-CAT High Heat Load monochromator alignment.

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Abstract

Here is a brief description of the procedure for aligning the MHATT-CAT High Heat Load monochromator. This work was done with John Pitney and Ron Pindak, with the goal of optimizing the flux near 13 keV. During this run, we found that the Se absorption edge could be scanned reproducibly with the monochromator, but found a factor 90 missing in the total flux. In early May 2000, the monochromator was realigned, and the flux is now in fair agreement with calculations.

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TABLES

TABLE I. EPICS channels and description of the monochromator motors.

Description	EPICS channel	EPICS channel Description	Units
First crystal Bragg angle	7ida:m13	hhlt	degree
Table Horizontal Upstream x1	7ida:m14	hhlx1	mm
Table Horizontal Downstream x2	7ida:m15	hhlx2	mm
Table height z1	7ida:m16	hhlz1	mm
Table height z2	7ida:m17	hhlz2	mm
Table height z3	7ida:m18	hhlz3	mm
Second crystal chi	7ida2:m31	pchi	step (0.3 μrad)
Second crystal theta	7ida2:m32	pth	step (0.3 μrad)
Second crystal theta	7ID_HHLM_piezo		0-10 V gives 0-300 μrad

This should be a good introduction for anyone needing to align the MHATT-CAT monochromator. The monochromator is a BESSRC type monochromator, with a fixed 35 mm offset [1]. The two crystals are Si (111), and the range of operation is 5 to about 40 degrees. Our MHATT-CAT High Heat Load Mono is motorized with 8 motors, 6 stepper motors and 2 picomotors. The name and EPICS channels are shown in Table I.

The first crystal is housed inside a UHV chamber and the beam angle of incidence is set by a vacuum prepared Huber circle (hhlt). The second crystal is mounted on a translation system which maintains a fixed exit beam offset [1]. The second crystal angles of incidence chi (pchi) and theta (pth) can be adjusted with two picomotors. These motors are good for tweaking, but cannot be scanned reproducibly. Positive steps in pchi moves the beam **outboard**.

An electrostrictive transducer (MT15-UVAC), driven by an MC-10 controller from Queensgate allows for small tweaks of the second crystal angle and can be used for feedback. This process variable is 7ID_HHLM_piezo for the drive PV and 7ID_HHLM_piezo_RBV as the readback value. Fig. 1 shows the tilt of the second crystal as a function of the voltage applied on the MC-10 input (PV units are in Volts). The calibration was done using a tiltsensor placed on the second crystal.

FIGURES

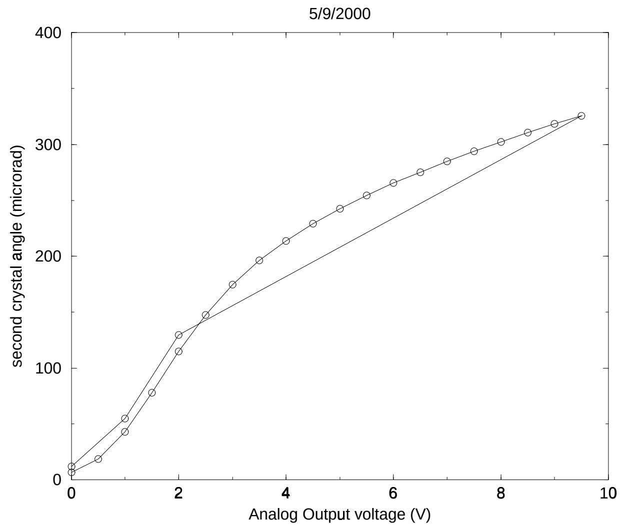

FIG. 1. MT15-UVAC calibration curve.

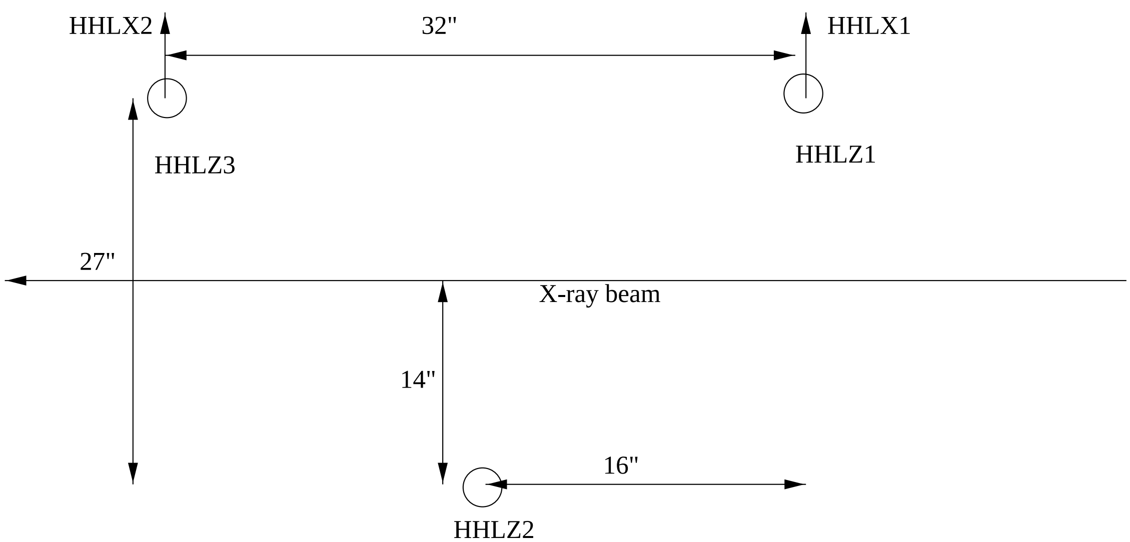

FIG. 2. Top view of the monochromator table.

The vacuum chamber housing the two crystals can be moved by five stepper motors. Fig. 2 shows the monochromator table. Three vertical translation stages (hhlz1, hhlz2, hhlz3) can move the crystal in an out of the beam. During white beam operations, the chamber is lowered typically by 4 mm to pass beam and the first crystal angle is returned to zero. The three motors have clutches which need to be energized in order to free the stage axis. **Do not move these motors unless the drives are powered, and the clutches activated.** Hhlz1 is the most upstream motor, hhlz3 the most downstream. The positive direction moves the table up. Two table motors move the table horizontally, transverse to the beam direction. The upstream motor is hhlx1, the downstream one hhlx2, and the positive direction moves the table inboard. These motor drivers are typically turned off. Moving the two motors in the same direction provides a transverse horizontal displacement, while moving them in opposite directions rotates the chamber around a vertical axis of rotation. These two motors allow for horizontally aligning the first crystal thin web in the beam [2] (see also Fig. 5).

The alignment procedure can be done with a standard APS fluorescent screen and a video camera, after slitting down the white beam white the L5-20 to say 200 μm by 200 μm. In the alignment procedure described below, an ion chamber in air was used. A 3 mm Al filter was placed upstream of the ion chamber to make its response more linear. For large ion chamber currents, the response becomes non-linear, so an He environment can also help to reduce the signal non-linearity.

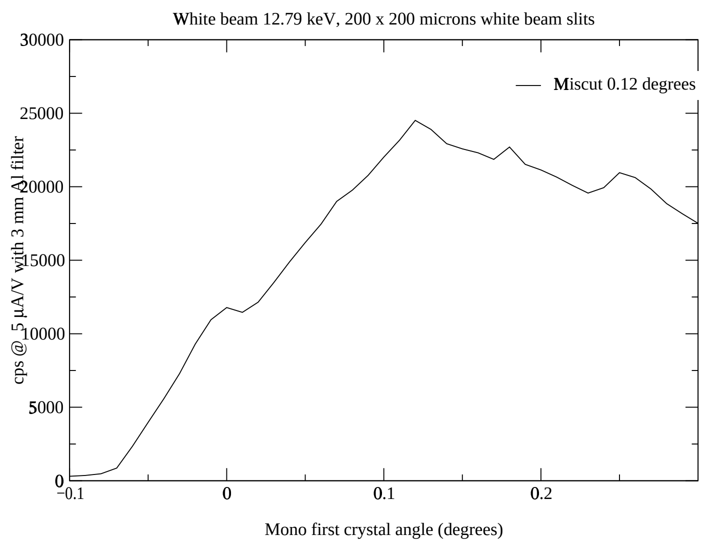

FIG. 3. Aligning the zero of the first crystal theta. The first crystal has a miscut of about 0.12 degrees.

The first step of the alignment procedure is to bring the monochromator angle to zero, and then align it parallel to the beam. Fig. 3 shows a scan of hhlt when the first crystal is nearly bisecting the beam. The peak occurs when the crystal is parallel to the main beam. The two different slopes are caused by the fact that the first crystal center of rotation is off centered. The smallest lever arm is 1.35 inches. The miscut is 0.1244 degrees. Since this last measurement, we've installed a new crystal which has another value for its miscut but its orientation has not been carefully characterized yet.

Note also that one can align the mono first crystal zero by looking at the externally reflected beam from the top Si surface, in ID-B using a YAG/Camera detector. Observation of the reflected beam is limited though to about 6mm/5m = 1.2 mrad due to the $\pm$ 6 mm aperture of the exit Be window downstream of the micromono, 5 m downstream of the first crystal.

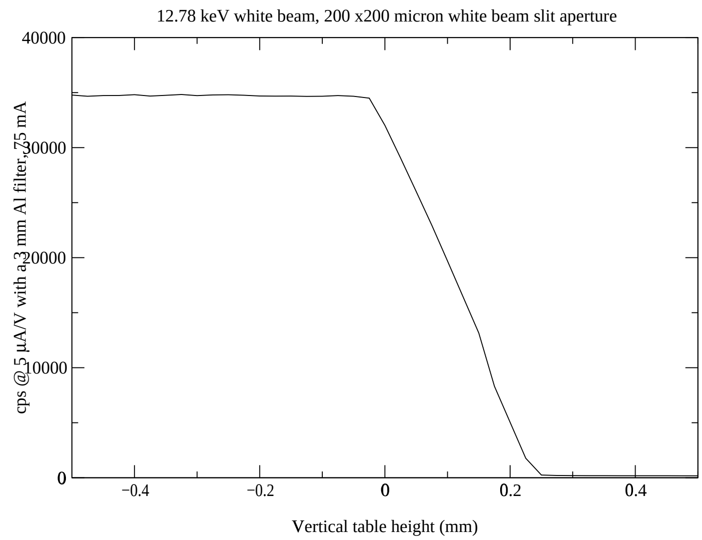

FIG. 4. Aligning the height of the first crystal.

Once the crystal is parallel to the beam, then we can bisect the beam again more adequately. Fig. 4 sh

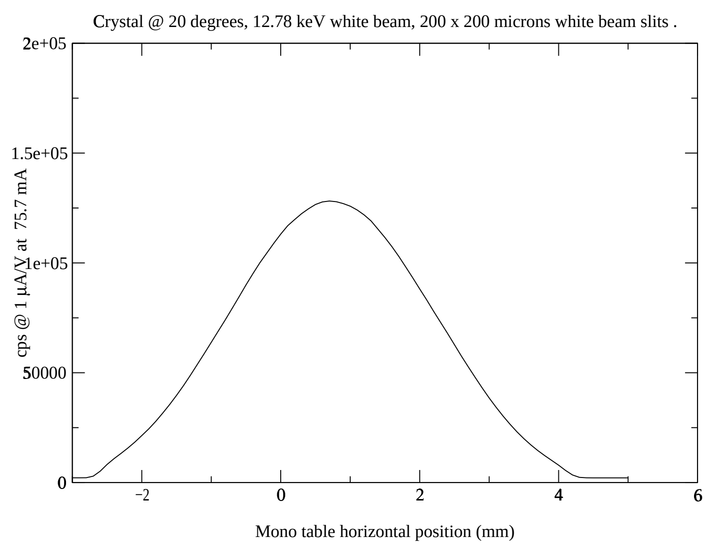

FIG. 5. Aligning the horizontal position of the first crystal.

Since the first crystal has been slotted to reduce the thickness of the crystal to 0.635 mm in order to reduce the absorbed power, with the first crystal at a sufficient large angle (here 20 degrees), it is possible to measure a transmission peak when the crystal is scanned transversely in the beam. Figure 5 shows that the previous zero was off by 0.7 mm. In the future, we should also try to rotate the chamber to make sure the slot axis was aligned longitudinally. Scanning hhlx1 and hhlx2 in opposite directions will do the trick.

The next step for the alignment is to move to the working Bragg angle for a given energy. For reference, the Si (111) lattice parameter is 2d = 6.271 Å. Then one needs to align the second crystal theta by tweaking the second crystal angle pth. The monochromatic beam should be directly above the white beam so if any horizontal offset is present, it is possible to move the beam by tweaking pchi. The easiest way to check for this offset would be to set a fluorescent screen on the exit window of ID-B and make a vertical reference line where the white beam hits to align the monochromatic beam.

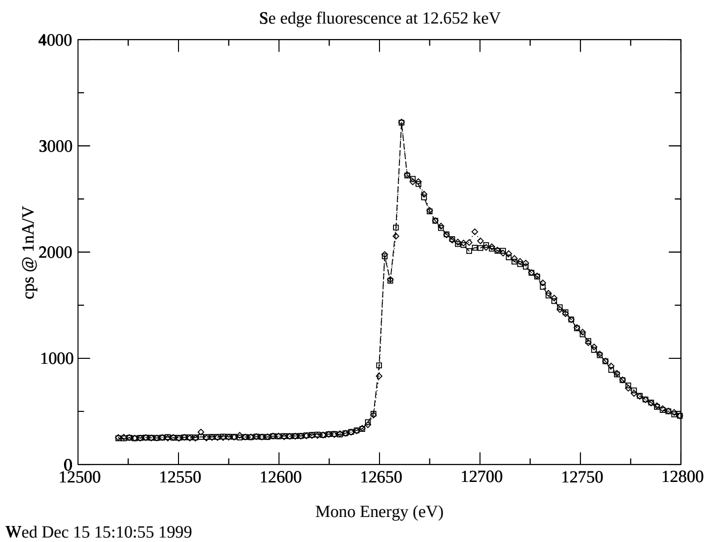

FIG. 6. Se edge calibration. The edge is at 12658 eV.

To calibrate the energy of the monochromator, I typically look at a Cu absorption edge at 8979 eV. Fig. 6 shows the reproducibility of an energy scan of the monochromator near the Se K edge. The ion chamber was placed after the sample, at 90 degrees from the main beam to only detect the fluorescence signal. The reproducibility at this energy was excellent. Our previous calibration was slightly off by a few eV.

For future reference, I also report the measured flux as a function of the monochromator energy in Table II and Fig. 7. The alignment was done for several fixed monochromator energy. At each energy, the undulator gap was scanned to optimize the flux. **Note that energy scans of the undulator should always be done from large to small gap or from high to low energy on the harmonics because the encoders have been calibrated for closing.** For this measurement, the white beam slits were opened to 1 mm and 0.6 mm in the horizontal and vertical direction respectively. The flux is a factor 189 less at 12.66 keV than it was at 8.86 keV. A theoretical estimate is also shown next to it but only changes by a factor 2.1 over the full energy range, thus we are effectively loosing a factor 89 in our alignment. Fig. 7 shows the measured flux on the first and third harmonics, and compares it to the calculated flux for n = 1 and n = 3. The calculation included the transmission of the commissioning window, and 4 Be windows. The calculated energy where it would be helpful to move to the third harmonics is 11 keV.

The measured flux was a factor 2.5 higher on the third harmonics than it was on the fundamental at 12.658 keV. Since the power load increased substantially at closed gap, the interval between fills of the cryocooler Dewar was reduced from approximately 4 to 2 hours. The Lucent group found that during the cryocooler fill which lasts 20-25 minutes, the beam intensity changed substantially. Thus the availability of stable beam was reduced substantially by going to the third harmonics.

Bragg angle degree	Mono Energy keV	Undulator Energy keV	Flux ph/s/100 mA	Calculated flux ph/s/100 mA	Ratio
12.899	8.857	9.25	3.34E12	1.84E13	5.5
11.45	10.0	10.45	1.85E12	1.82E13	9.8
10.35	11.0	11.85	7.51E11	1.58E13	21
9.48	12.0	12.95	9.35E10	1.26E13	135
8.986	12.658	12.82	1.77E10	8.7E12	492

TABLE II. Measured monochromatic flux in a 0.6 mm (vertical) by 1 mm (horizontal) beam at 26.5 m. A theoretical estimate is also shown for a monochromatic beam filtered by the commissioning window and 4 beamline Be windows. The filtering here reduces the energy dependence of the tuning curve (which varies by a factor of 6 over the energy range), because of the window absorption at lower energies. The ratio of the calculated flux over the measured flux is also shown.

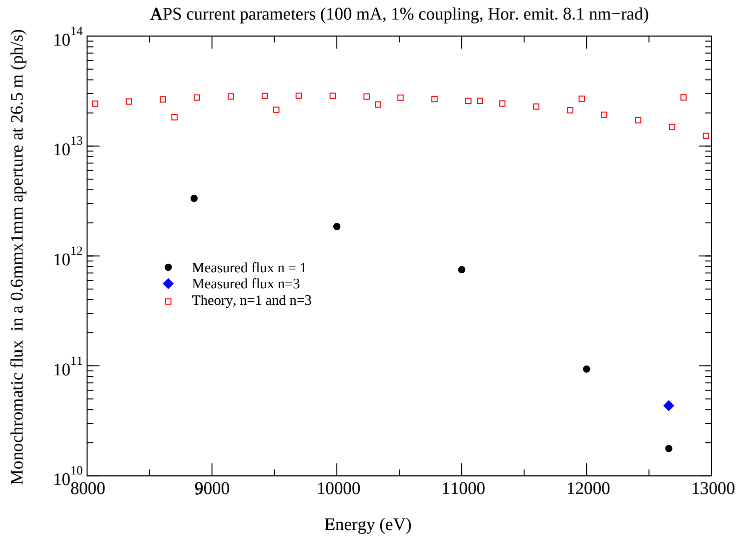

FIG. 7. Comparison of measured (square) and predicted flux (circles).

Since these notes were written last December, we've carefully realigned the monochromator in early May 2000. We found that the large slide of the mono was 1.6 degree off from the horizontal when the first crystal was horizontal. It seemed at the time that they should be parallel at all angles including zero, so we realigned the first crystal with respect to the slide. After these changes, the first and second crystal had to be moved down 5 mm and the tank up 5mm.

Table III shows the results of a rough calibration of the monochromator at the end of June 2000. The measurements here were corrected for air-path absorption of 131.5 cm. The agreement is fairly good, and within a factor 3 below 11 keV.

Bragg angle degree	Mono Energy keV	Undulator Energy keV	Flux ph/s/100 mA	Calculated flux ph/s/100 mA	Ratio
11.40	10.0	10.063	1.1E13	3.64E13	3.2
10.35	11.0	11.078	9.9E12	3.16E13	3.2
9.48	12.0	12.088	6.3E12	2.52E13	4.0
8.75	13.0	13.088 (n=1)	2.7E12	1.74E13	6.4
8.75	13.0	13.088 (n=3)	7.7E12	n.a.	n.a.
8.2371	13.8	13.9 (n=3)	6.1E12	n.a.	n.a.

TABLE III. Measured monochromatic flux measured in 7ID-C at 49.5 m, with the white beam slits set to 0.6 mm (vertical) by 2 mm (horizontal). The theoretical estimate shown use the previous theroretical estmate times two. The agreement between the calculation and measurement has improved by a factor of about 60 after the last alignment in May 2000.

To conclude, I hope that these hints will be helpful to help with the alignment of the High Heat Load Mono in future runs. The missing flux was afterall caused by a misalignment of the two crystals with respect to each others.

REFERENCES

[1] M. Ramanathan et al., Rev. Sci. Instrum. **66**, 2191 (1995).

[2] G.S. Knapp et al., Rev. Sci. Instrum. **66**, 2138 (1995).